MATERIALS FOR PARACHUTES OF THE FUTURE

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This paper is going to be very different from the previous papers. It is, by no means, an academic paper. But please don't misinterpret me. For many years now, I have, as probably you know, initiated work of the nature that you've seen this afternoon. And it has been my job to put that in terms of parachute design to meet operational requirements to fill that job. That job is still mine. And I am going to go a little further, probably stick my neck out a mile, and suggest what we think in Great Britain we shall use in the next four or five years for parachutes to meet the major requirements, rather than perhaps individual requirements.

We will all appreciate, I feel sure, that, although the ultimate requirements for parachutes to operate satisfactorily at higher speeds and altitudes may be common to both countries, the particular materials we use may vary tremendously because of differences in (a) the parachute design, and (b) facilities for preservation of these materials. The latter point, I feel, may apply to us in Great Britain much more than here. Thus, whereas one designer may wish to use a very thin fabric, he may be forced, through lack of suitable yarn, to use a much thicker fabric.

The bulk of a parachute is of great importance. Consequently, we, as designers of parachutes, must forever strive to produce materials of a greater strength-to-bulk ratio. Bulk is not necessarily associated with weight, for we may increase the ends and picks of a plain weave fabric without increasing its thickness. But, of course, we would change its weight and porosity. We are constantly being pressed to reduce the dimensions of our packed parachutes, for they are carried on aircraft where weight and space are limited. The particular argument put forward is to reduce the thickness of our back type emergency parachutes by half an inch. The aircraft designer can reduce the length of the cockpit by the same amount. Reduction of bulk of a parachute assembly is primarily a matter of design. If high shock loads during opening can be avoided, weaker materials can be used, particularly in the rigging lines. Consequently, bulk is reduced.

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Simplicity in shape is also an important factor, for simple shapes pack easily. Although, I suppose, the designer has already made use of his skills in these ways, there's still room for improvement. Canopy bulk is also dependent on fabric thickness. This, in turn, is dependent on the denier of the yarn, which is further dependent on the strength of the material used. Therefore, if we are to reduce the bulk, we must seek not only the strongest materials, but the smallest yarn to obtain the thinnest fabric. For a given denier, the thickness is inversely proportional to the square root of the specific gravity. Hence, the material, such as celanese fortisan, which has a higher specific gravity than nylon, produces a thinner frabric from yarns of the same denier.

I have emphasized this point about thickness of fabric and the correct denier yarn because we in the UK are often forced to use much higher denier yarns for canopies than we require, either because there are no facilities for producing the smaller yarns, or because export of other goods made from the same materials is of greater importance than producing parachutes.

We would like to obtain 25 or 30 denier yarns of celanese fortisan, nylon or terylene. I should add here that it seems that we can't even agree on standardizing the name; so I hope you will understand that we in England call it terylene, and I think you here call it Dacron. Such yarns would give us sufficient strength and at the same time produce a fabric which is about 2 thousandths of an inch thick. For reasons which I have just explained, we have been safe to use 45 denier nylon, which gives us a fabric about twice as thick. Low bulk is also achieved by using a plain weave; however, if we use low denier synthetic yarns, it does not appear to be a practical proposition to produce a low porosity fabric in a plain weave, because relatively high twist is necessary to obtain a uniform porosity.

I have already suggested that we shall look to celanese fortisan, nylon and terylene for canopy fabrics of the future. My own view - although we have developed nylon for parachute fabrics and we now use it almost exclusively - is that it is not a very desirable material. Its main defects are: it has a low melting point and therefore requires much protection from high temperature during the pack state and also during deployment. It sears easily and so maintenance costs are heavy. It has a low coefficient of friction. You see how we differ, even in our own requirements when you compare this with what the other gentlemen have said this afternoon. And so frequent abnormalities occur during deployment. I'm quite unable to speak about terylene as so far we have been unable to obtain any fabrics suitable for parachutes. In fact, the date given to me in England is something like 1956. Celanese fortisan because of its higher specific gravity produces a thinner fabric than nylon of the same denier and terylene would appear to be superior to nylon because of its higher melting point.

As far as I can foresee, we shall need fabrics of 40 to 80 pounds per inch tensile strength for the large parachutes we propose using for emergency and for supply drops. For smaller parachutes, which are generally required to deploy and open fully at very high speeds, we shall probably need fabrics ranging in strength from about 100 to 300 pounds per inch.

I have already stated that bulk is of lesser importance than the design of these small parachutes and plain weaves may not be possible because of the need for a high denier yarn and a high porosity fabric. There is no evidence to suggest that the elasticity plays any important part in canopy fabrics. We shall probably design most of our parachutes to use porous fabrics. However, where stability is the most important factor, we may use imporous fabrics of high tensile strength for canopies of the guide service type.

It is my personal opinion that ribbon parachutes are with us for some time, particularly for such work as braking of aircraft. I know you will all agree with me. Because of the low shock loads experienced during the opening of ribbon parachutes, the strengths of the materials used are less than those in either a flat or a shaped solid canopy, which are the types we most frequently use. And so the bulk and the total cost of production are less for the same drag.

Rigging lines usually occupy between 50 and 70 percent of the total volume of the parachute. It is therefore imperative that we should investigate any reduction in bulk by changing the design of the parachute or by improving the strength-to-bulk ratio of the cordage, by following your lead and gradually changing from a round to a flat cord. In the past, we have tended to use round cordage for tensile strengths up to about 1200 pounds and use a hollow braid for greater strengths. The main reason for using these types of cordage was that in order to meet peak production required of us during the war, only certain machines were available. We are now tending to replace both types by a flat woven cordage, which results in a substantial reduction in bulk without a loss of elasticity. Nylon is used exclusively for all rigging line cordage. Again, contrary to your experiences, I believe, we have had much difficulty in using nylon sewing thread for manufacturing parachutes. I must add that manufacturers of other articles did not appear to have the same difficulties and so I am prepared to accept criticisms for our failures with parachutes. It appears that a good stitch can only be obtained if there is practically no tension in the thread and also if the atmosphere conditions are just right. Now, what those conditions are, I do not know. We find that working conditions are very critical and that khaki dyed thread is completely unsatisfactory in conditions where a natural thread gives a good stitch. And, for these reasons, we have gone back to a strong silk thread. So far we have not used nylon extensively for packs. We prefer using cotton even if it be a low grade. Cotton must, of course, be proved, and we usually use a khaki mineral dye. Such materials have proved to be satisfactory, both in manufacture and use, and I don't think we should change.

At one time, we thought about developing a nylon harness for emergency parachutes. We found difficulties, as did others, producing a suitable webbing which would withstand rubbing without fluffing, was stiff enough to withstand curling without being excessively strong and costly, and had sufficiently rough surface to prevent slipping throught the metal fittings in normal use. The whole development was stopped because a satisfactory harness would have required a redesign of the metal fittings. That we weren't prepared to do. We have, therefore, retained our flax webbing harness, which has given us most satisfactory service for a long period.